DOCUMENT RESUME

ED 235 042 SE 043 335

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TITLE Methane Digestors. Third World Science.
INSTITUTION University Coll. of North Wales, Bangor (United Kingdom). School of Educaton.
SPONS AGENCY Training Services Agency, London (England).
PUB DATE 82
NOTE 29p.
AVAILABLE FROM The Centre for World Development Education, 128 Buckingham Palace Road, London SW1W 9SH.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Chemical Reactions; Cultural Activities; *Developing Nations; Elementary School Science; Foreign Countries; *Fuels; Intermediate Grades; *Microbiology; Quality of Life; Science Education; *Science Experiments; Secondary Education; *Secondary School Science; Sludge; Wastes
IDENTIFIERS *Methane Digestors; Sri Lanka; *Third World Science Project; United Kingdom

ABSTRACT

This unit, developed by the Third World Science Project, is designed to add a multicultural element to existing science syllabi (for students aged 11-16) in the United Kingdom. The project seeks to develop an appreciation of the: boundless fascination of the natural world; knowledge, skills, and expertise possessed by men/women everywhere; application of knowledge and skills to solve the practical problems of everyday life; impact of modern technology in the world; and the influence of the cultural background on the perception of knowledge, problems, and solutions. The unit begins with a discussion of the viability of and technology involved in producing methane from waste materials, followed by information on: physical/chemical properties of biogas; basic theory of anaerobic breakdown of materials into methane; differences between aerobic/anaerobic methods in methane digestors; reproduction of the anaerobic process in air-tight containers; and role of different bacteria in the biological breakdown of wastes in digestors. A discussion of what kind of digestor should be built and best way of using gas/slurry produced follows. A report on the role of the integrated biogas system in Sri Lanka (illustrating benefits for a country lacking in fossil fuels) and a description of how small digestors can be constructed using school materials are included. (JN)

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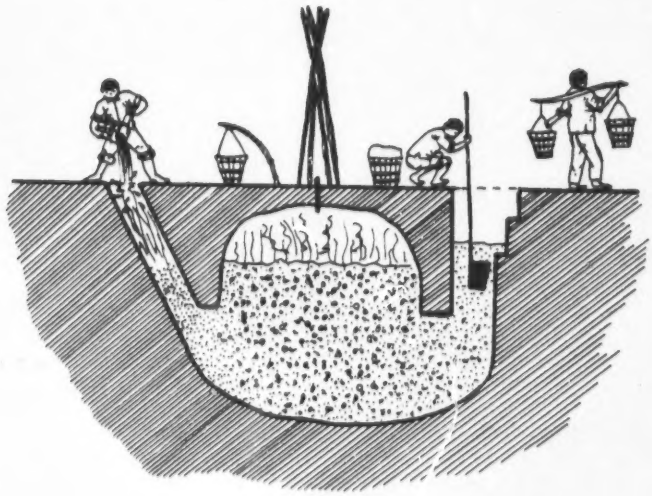

METHANE DIGESTORS

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THIRD WORLD SCIENCE

Third World Science seeks to develop an appreciation of:

1 The boundless fascination of the natural world

2 The knowledge, skills and expertise possessed by men and women everywhere

3 The application of knowledge, skills and expertise to solve the practical problems of everyday life

4 The impact of modern technology in the third world

5 The influence of the cultural background on the perception of knowledge, problems and solutions

The following Units have been designed to fit into existing science syllabuses in the United Kingdom:

CARRYING LOADS ON HEADS: CHARCOAL: CLAY POTS:
DENTAL CARE: DISTILLATION: ENERGY CONVERTORS:
FERMENTATION: HOUSING: IRON SMELTING: METHANE DIGESTORS:
NATURAL DYES: PLANTS AND MEDICINES: SALT: SOAP.

The method of use is not closely prescribed. As resources teachers may use them in different ways though suggestions are offered. Feedback is invited from teachers concerning (a) the use made of the material (b) pupils reactions, if possible in their own words, and (c) suggestions for improvements, additions etc.

Please send feedback, ideas and requests to:

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METHANE DIGESTORS

Teacher's Notes

The unit begins with a short introduction which outlines the viability of producing methane from waste materials, and the technology involved. This is followed by general information on biogas looking at the physical and chemical properties and also the calorific value of the gas with some examples of how gas may be used. The basic theory of how waste materials are broken down into methane anaerobically is followed, in some detail, by the necessary conditions, for successful digestion., The section on methane digestors outlines the differences between aerobic and anaerobic methods of breaking down waste materials and then goes on to explain how the anaerobic process can be reproduced in an air tight container. This is then followed by a section on the biology of digestion which explains the roles of different bacteria under certain conditions.

The unit continues with a section on synergy at work which entails looking at what kind of digestor should be built and what is the best way of using the gas and slurry produced.

A report on the role of integrated biogas system in Sri Lanka is included to show how methane digestors can benefit a country,which is lacking in fossil fuels and capital,in several different ways.

The unit concludes with a discription of how a small methane digestor can be set up using materials available in a school laboratory.

METHANE DIGESTORS

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Introduction

The need to conserve resources and to find alternative sources of energy are becoming major concerns of most governments. Also, international assistance programmes are increasingly emphasising the need to employ technology in rural areas that is within the technical, social and economic capacities of the people for whom it is intended.

One way of bringing together both of these needs is through a renewed look at the use of "wastes" - both human and animal. In most so-called developed countries, human wastes are regarded as unwanted by-products and discharged as pollutants into the surrounding environment. However in China, such wastes are looked upon as out-of-place resources and valued as low-cost sources of energy to be treated and re-cycled into the production process.

Biogas technology is based on the phenomenon that when organic matter containing cellulose is fermented in the absence of air (anaerobically) a combustible gas (methane) is formed. The technology associated with the production of methane at the village level is in a much greater state of change than is popularly assumed. With the fluid state of biogas technology and the unusual interest currently being shown in it, it would seem to be relatively easy to design and build biogas plants that could be operated in rural situations to meet certain social objectives and yet still complete with 'higher' technologies even in conventional terms of profit and capital per unit of output.

The viability of a particular biogas plant design depends on the particular environment in which it operates. Therefore, the research problem becomes one of providing a structure in which technologists, economists, and users of technology can combine to produce both the appropriate hardware for various situations and the infrastructure that is necessary to ensure that the hardware is widely used. There is a need to examine a wider range of technical and economic alternatives for meeting the energy and fertilizer needs of rural people.

GENERAL INFORMATION ABOUT BIOGAS

What is biogas?

Biogas is a flammable gas produced by microbes when organic materials are fermented in a certain range of temperatures, moisture contents, and acidities, under air tight conditions. In ponds, marshes and manure pits where there is a high content of rotting organic materials, you can often see bubbles coming up to the surface and if you lit them you would see a blue flame. Because this sort of gas is often seen in ponds and marshes it is also known as marshgas.

Biogas is a form of biological energy that can be synthesised. In nature there are many raw materials from which biogas can be extracted: human and animal manure, leaves, twigs, grasses, stalks from crops, garbage, and also some agricultural and industrial wastes whose organic content is greater than 2%. These materials can produce biogas when placed out of contact with air and disintegrated by microbes. Biogas can then be used for cooking and lighting and in internal combustion engines

Physical and chemical properties of biogas

Biogas is a mixture of methane (CH_4 60-70%), carbon dioxide (CO_2), and small quantities of hydrogen sulphide (H_2S), nitrogen (N_2), hydrogen (H_2), and carbonmonoxide (CO), and several other hydrocarbon compounds.

Methane itself is odourless, colourless and tasteless, but the other gases contained in biogas give it a slight smell of garlic or rotten eggs.

The weight of methane is roughly half that of air.

$$\frac{\text{1 cu.m of methane}}{\text{1 cu.m of air}} = \frac{0.716 \text{ kg}}{1.293 \text{ kg}} = 0.554$$

The solubility of methane in water is very low. At 20°C and 1 atmosphere pressure, only three units of methane (volume) can be dissolved in 100 units of water. Methane has a chemical formula of CH_4 and a molecular weight of 16.04; it is very stable hydrocarbon compound.

The complete combustion of methane produces a blue flame and a great amount of heat, The chemical reaction is:

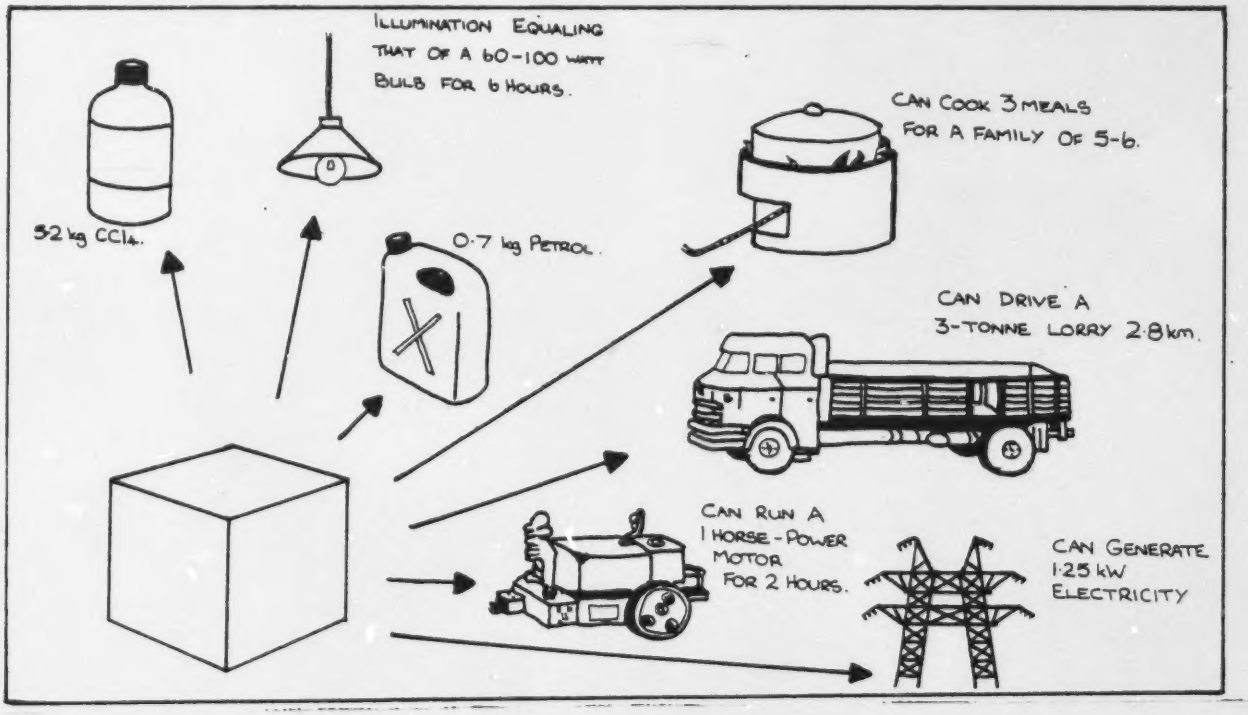
$$CH_4 + 2O_2 \longrightarrow CO_2\uparrow + H_2O \quad \Delta H_c = -50.5 \text{ kJ}$$

Upon complete combustion one cu. m. of methane can reach a temperature of 1400°C and release 2040-2260 kilojoules of heat (1 kJ of heat will raise the temperature of 1 litre of water by 4.2°C). On complete combustion 1 m^3 of biogas can release 1320-1550 kJ of heat.

Methane is an important raw material for chemical industries; it can be used in the production of monochloromethane, dichloromethane, chloroform (which is also a chief source of carbon tetra-chloride), acetylene, methanol etc.

Uses of biogas

Biogas can be used as a high quality fuel for cooking and lighting. One cu.m can keep one biogas lamp of a luminosity equivalent to a 60 watt electric light burning for six to seven hours. Biogas is also a superior fuel for producing power. One cu.m can keep a 1 hp internal combustion engine working for two hours - roughly equivalent to 0.6-7.7 kg of petrol. It can generate 1.25 kwh of electricity.


ILLUMINATION EQUALING THAT OF A 60-100 WATT BULB FOR 6 HOURS.
CAN COOK 3 MEALS FOR A FAMILY OF 5-6.
32 kg CCl4.
0·7 kg PETROL.
CAN DRIVE A 3-TONNE LORRY 2·8km.
CAN RUN A 1 HORSE-POWER MOTOR FOR 2 HOURS.
CAN GENERATE 1·25 kW ELECTRICITY

The theory and conditions for manufacturing biogas

In order to ensure the controlled fermentation of biogas and a rapid rate of production, one must understand the fundamentals of fermentation, and the conditions necessary for it to occur.

Basic theory

The fermentation process is a complicated one involving two main stages:

Stage 1: Bacteria break down complex organic materials, such as carbohydrate and chain molecules, fruit acid material, protein and fats. The disintegration produces acetic acid, lactic acid, propanoic acid, butanoic acid, methanol, ethanol and butanol, as well as carbon dioxide, hydrogen, hydrogen sulphide and other non-organic materials.

In this stage the chief micro-organisms are ones that break down polymers, fats, proteins and fruit acids, and the main action is the butanoic fermentation of polymers.

Stage 2: The simple organic materials and CO_2 that have been produced are either oxidised or reduced to methane by micro-organisms, the chief ones being the methane-producing or methanogenic micro-organisms of which there are many varieties. These need a supply of nitrogen and the latter provided by the carbon are simple organic acids and alcohols which are produced by fermentation from polymers, fats and other carbohydrates. These are broken down into methane, and carbon dioxide. This stage may be represented by the following overall reaction:

$(C_6H_{10}O_5)n + nH_2O$ *through the action of methane bacteria* $3nCH4 + 3nCO_2$ + *heat*

Individual reaction include:

i. Acid breakdown into methane.

$$2C_3H_7COOH + H_2O \longrightarrow 5CH_4 + 3CO_2$$

ii. Oxidation of ethanol by CO_2 to produce methane and acetic acid

$$2CH_3CH_2OH + CO_2 \longrightarrow 2CH_3COOH + CH_4$$

iii. Reduction with hydrogen of carbon dioxide to produce methane.

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

Thus, complex organic materials are broken down through the action of micro-organisms to produce simple organic acids, alcohols, CO_2 etc., which are then oxidised by micro-organisms to produce methane.

This is a complete biological and chemical process and a balance must be maintained between the two stages. If the first stage proceeds at a much higher rate than the second, acid will accumulate and inhibit the fermentation in the second stage, slow it down and actually stop it.

Necessary conditions for fermentation

Since this fermentation is the result of the action of many sorts of anaerobic micro-organisms, the better the living environment of these micro-

organisms, the faster the production of biogas. If proper conditions cannot be maintained, biogas production will slow or cease altogther. Optimal living conditions for these micro-organisms are:

Airtightness

None of these biological activities of anaerobic micro-organisms, including their development, breeding and metabolism, requires oxygen: in fact they are very sensitive to the presence of oxygen. The breakdown of organic material in the presence of oxygen will produce carbon dioxide; in airless conditions it will produce methane. If the biogas pit is not sealed to ensure the absence of air the action of the micro-organisms and production of biogas will be inhibited and some will escape. It is therefore crucial that the biogas pit be watertight and airtight.

Suitable temperature

The temperature for fermentation in the pit will greatly affect the production of biogas. Under suitable temperature conditions the micro-organisms become more active and gas produced at a higher rate. Methane can be produced within a fairly wide range of temperature, depending on prevailing conditions. Three types of fermentation are possible: at high medium and ordinary temperatures. For high temperature fermentation, the temperature should be 50-55^{o}C; for medium, 30-35^{o}C; and for ordinary temperature; 10-30^{o}C.

When the ambient temperature falls below zero, the temperature inside many biogas pits remains above 10^{o}C, so that production is still maintained. Methane micro-organisms are very sensitive to temperature changes; a sudden change exceeding 3^{o}C will affect production, therefore one must ensure relative stability of temperature.

Necessary nutrients

There should be plentiful material for the normal growth of the micro-organisms, and they must be able to extract plentiful nutrients from the source of fermentation. The main nutrients are carbon, nitrogen and inorganic salts. A specific ratio of carbon to nitrogen must be maintained, between 20:1 and 25:1. This ratio will vary for different raw materials, and sometimes even for the same ones. The main source of nitrogen is human and animal excrement, while the polymers in crop stalks are the main source of carbon. In order to maintain a proper ratio of carbon to nitrogen, there must be proper mixing of the human and animal excrements with polymer sources. Since there are few common material with a suitable ratio of carbon to nitrogen, production will generally not go well with one source of material

Water content

There must be suitable water content as the micro-organisms' excretive and other matabolic processes require water. The water content should normally be around 90% of the weight of the total contents. Both too much and too little water are harmful. With too much water the rate of production per unit volume in the pit will fall, preventing optimum use of the pit . If the water content is too low, acetic acids will accumulate, inhibiting the fermentation process and hence production, also, a rather thick scum will form on the surface. The water content should differ according to the difference in raw materials for fermentation.

Maintaining a suitable pH balance

The micro-organisms require a neutral or a mildly alkaline environment - too acidic or too alkaline environment will be detrimental. A pH between 7 and 8.5 is best for fermentation and normal gas production. The pH value for a fermentation pit depends on the ratio of acidity and the carbon dioxide on the ratio of acidity and alkalinity and the carbon dioxide content in the pit, the determining factor being detrimental. For the normal process of fermentation, the concentration of volatile acid measured by acetic acid should be below 2000 parts per million; too high a concentration will greatly inhibit the action of the methanorgenic micro-organisms.

Harmful materials

The micro-organisms that make the biogas are easily affected by many harmful materials which interfere with their livelihood. Maximum allowable concentrations of such harmful materials are as follows:

Sulphate (SO_4^{2-})	5,000 parts per million
Sodium chloride (NaCl)	40,000 parts per million
Copper (Cu)	100 milligrams per litre
Chromium (Cr)	200 milligrams per litre
Nickel (Ni)	200-500 milligrams per litre
Cyanide (CN^{2-})	below 25 milligrams per litre
ABS (detergent compound)	20-40 parts per million
Ammonia (NH_3)	1,500-3,000 milligrams per litre
Sodium (Na)	3,500-5,500 milligrams per litre
Potassium (K)	2,500-4,500 milligrams per litre
Calcium (Ca)	2,500-4,500 milligrams per litre
Magnesium (Mg)	1,000-1,500 milligrams per litre

Polluting substances such as these can only be accommodated if under these concentrations. They must either not be present or their concentration must be diluted, for example by the addition of water.

Methane Digestors

When organic material decays it yields useful by-products. The kind of by-product depends on the conditions under which decay takes place. Decay can be aerobic (with oxygen) or anaerobic (without oxygen). Any kind of organic matter can be broken down either way, but the end product will be quite different (Fig 1).

It is possible to copy and hasten the natural anaerobic process by putting organic waste (manure and vegetable matter) into insulated, air tight containers called digestors.

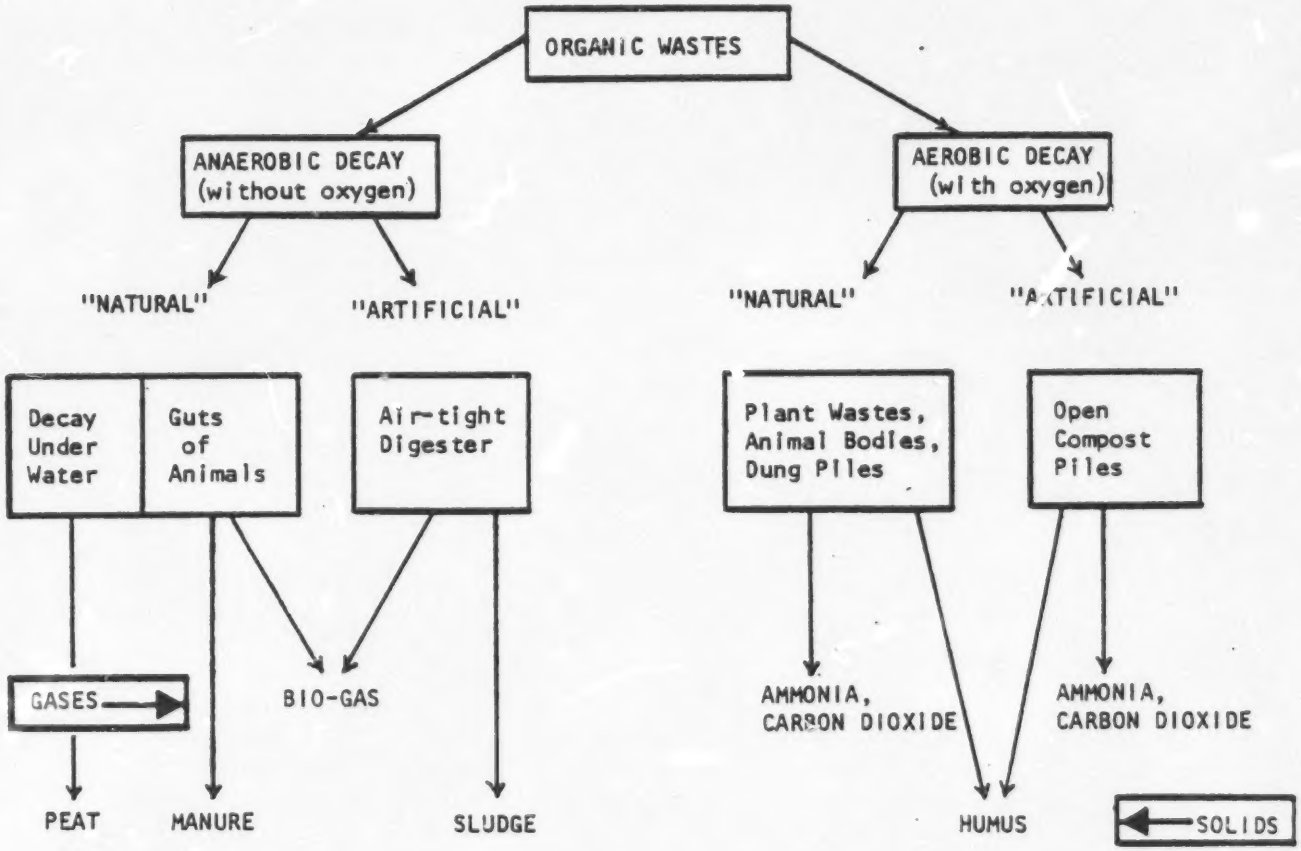


FIG.1 End Products of Organic Decay

There are two types of digestors:-

1) Batch-load digestors which are filled all at once, sealed and emptied when the raw material has stopped producing gas, and
2) Continuous-load digestors which are fed a little, regularly, so that gas and fertilizer are produced continuosly.

The digestor is fed with a mixture of water and wastes, called 'slurry'. Inside the digestor, each daily load of fresh slurry flows in one end and displaces the previous day's load which bacteria and other microbes have already started to digest.

Each load progresses down the length of the digestor to a point where the methane bacteria are active. At this point large bubbles force their way to the surface where gas accumulates. The gas is very similar to natural gas and can be burned directly for heat and light, stored for future use, or compressed to power heat engines.

Digestion gradually slows down toward the outlet end of the digestor and the residue begins to settle into distinct layers (Fig 2).

Sand and organic materials at the bottom.

Sludge, the spent solids of the original manure reduced to about 40% if the volume it occupied in the raw state. Liquid or dry sludge makes an excellent fertilizer for crops and pond cultures.

Supernatant, the spent liquids of the original slurry. The fertilizing volume of the liquid is as great as sludge, since the dissolved solids remain.

Scum, a mixture of coarse fibrous material, released from the raw manure, gas and liquid. The accumulation and removal of scum is important as large amounts can virtually shut down a digestor.

Phases		Useable Resources
Gas	Bio-gas	Combustion Gas
	Scum	Fertilizer Insulator
Liquid	Supernatant	Biologically active
Solid	Digested Sludge (spent slurry)	Fertilizer
	Inorganic Solids	

Fig 2 - Layering of By-products in the Digestor.

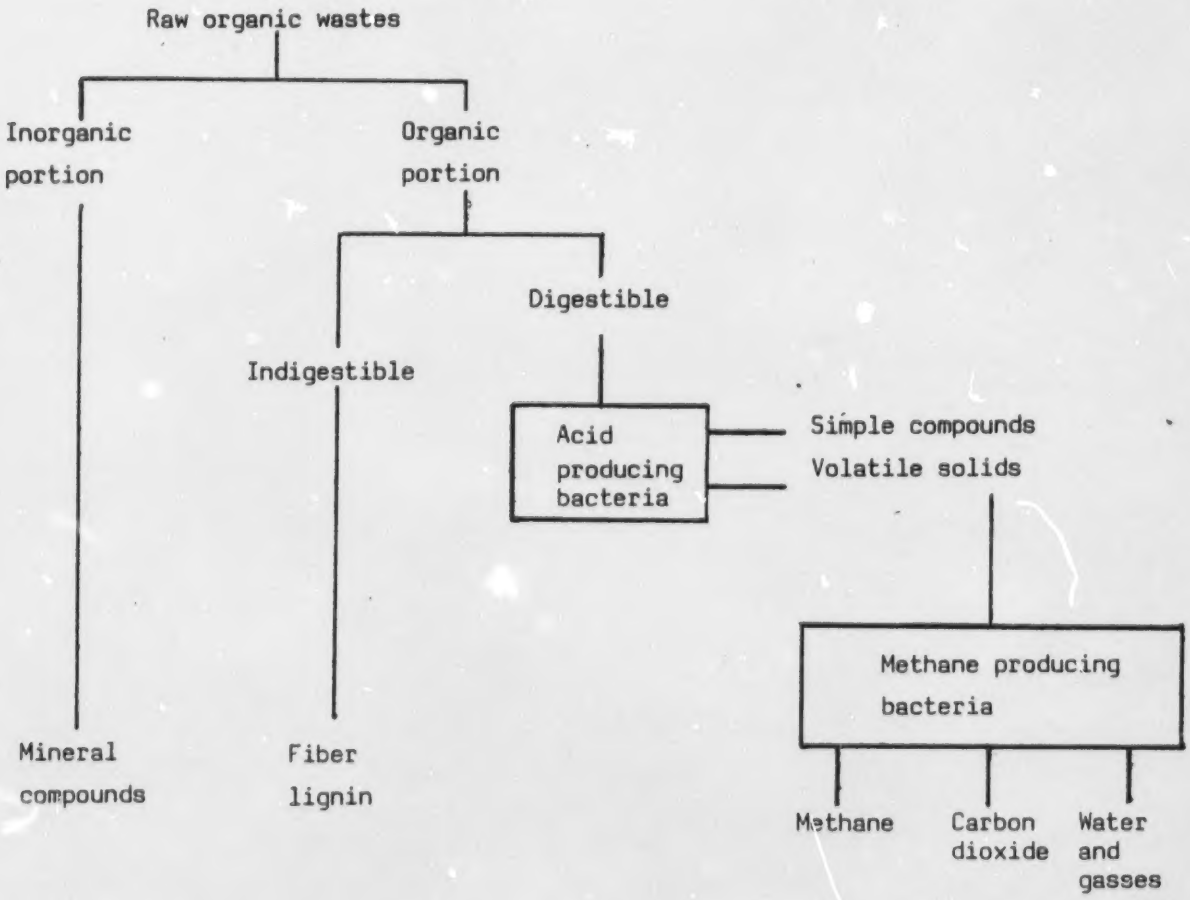
BIOLOGY OF DIGESTION

Perhaps the most important thing to remember is that digestion is a biological process.

The 'anaerobic' bacteria resposible for digestion can't survive with even the slightest trace of oxygen so, because of the oxygen in the manure mixture fed to the digestor, there is a long period after loading before actual digestion takes place. During this initial 'aerobic' period, traces of oxygen are used up by oxygen-loving bacteria, and large amounts of carbon dioxide (CO_2) are released.

When the oxygen disappears, the digestion process can begin. That process involves a series of reactions by several kinds of anaerobic bacteria feeding on the raw organic matter. As different kinds of these bacteria become active the by-products of the first bacteria provide the food for the other kind (see below).

The Biological Breakdown of Wastes in the Digestor



In the first stages of digestion, organic material which is digestible (fat, protein and most starches) are broken down by acid producing bacteria into simple compounds.

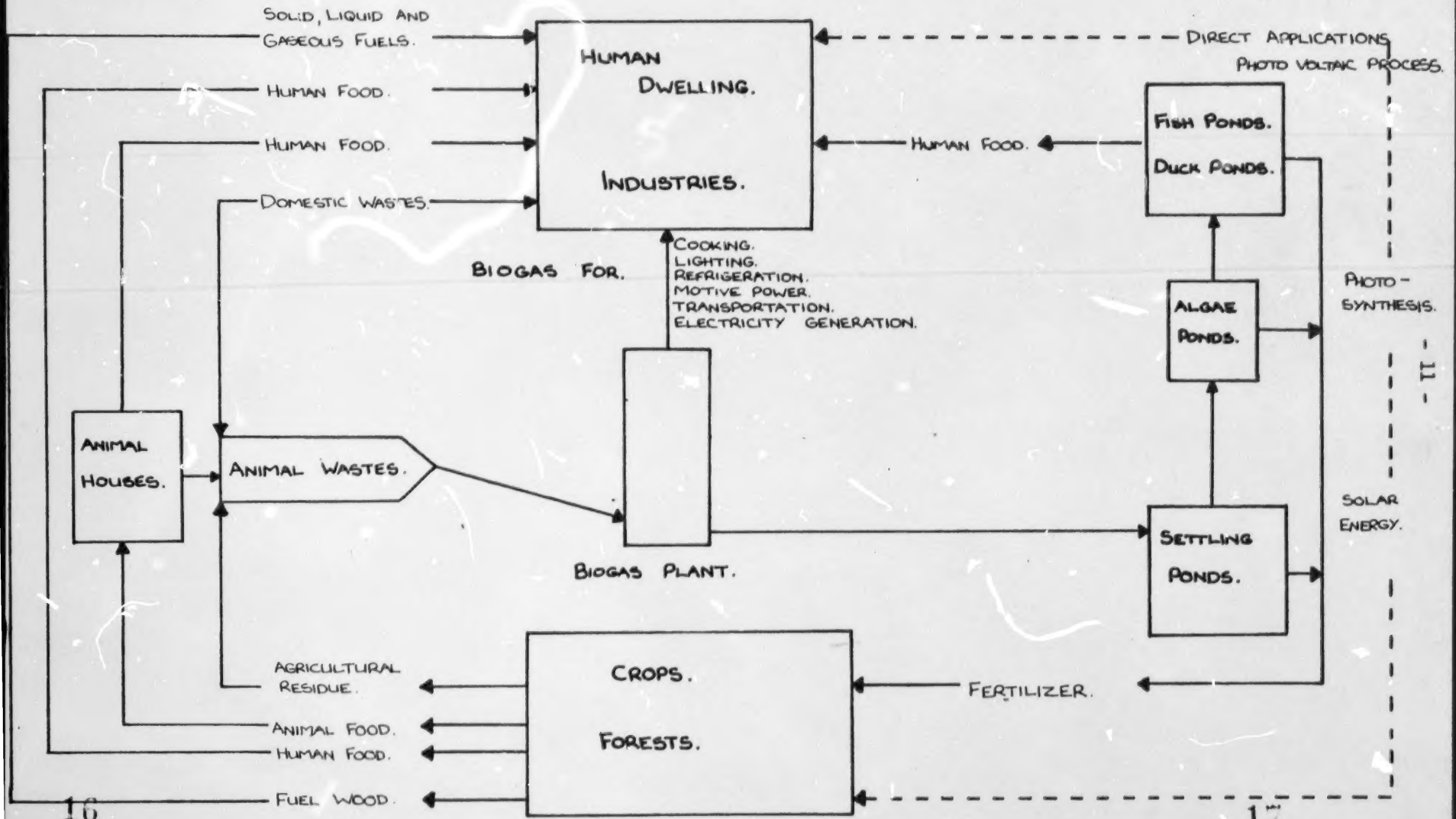
The acid bacteria are capable of rapid reproduction and are not very sensitive to changes in their environment. Their role is to excrete enzymes, liquefy the raw materials and convert the complete materials in simple substances (especially volatile acids, which are low molecular weight organic acids).

The most important acid, is acetic acid, a very common by-product of all fat, starch and protein digestion. About 70% of the methane produced during fermentation comes from acetic acid.

Once the raw material has been liquefied by the acid producing bacteria, methane producing bacteria converts the volatile acids into methane gas. Unlike the acid bacteria, methane bacteria repoduce slowly and are very sensitive to changes in the conditions of their environment.

Biologically successful digestion depends upon achieving and (for continuous load digestors) maintaining a balance between those bacteria which produce organic acids and those bacteria which produce methane gas from organic acids. This balance is achieved by a regular feeding with liquid, Proper pH, temperature and the quality of raw material in the digest.

COMPONENTS OF THE INTEGRATED BIO-ENERGY SYSTEM.



Methane - Gas Plant: Synergy at Work

When we consider digestors on a homestead scale, there are two general questions to ask:

1) With organic wastes and resources at hand, what kind of digestor should be built, and how big should it be?

2) What is the best way of using the gas and sludge produced to satisfy the energy needs of the people involved? (Whether the sludge should be used to fertilize crops, fish or algae ponds, and whether the gas should be used directly to heat, and light, or stored, or fed back to the digestor to heat it etc. Fig 3).

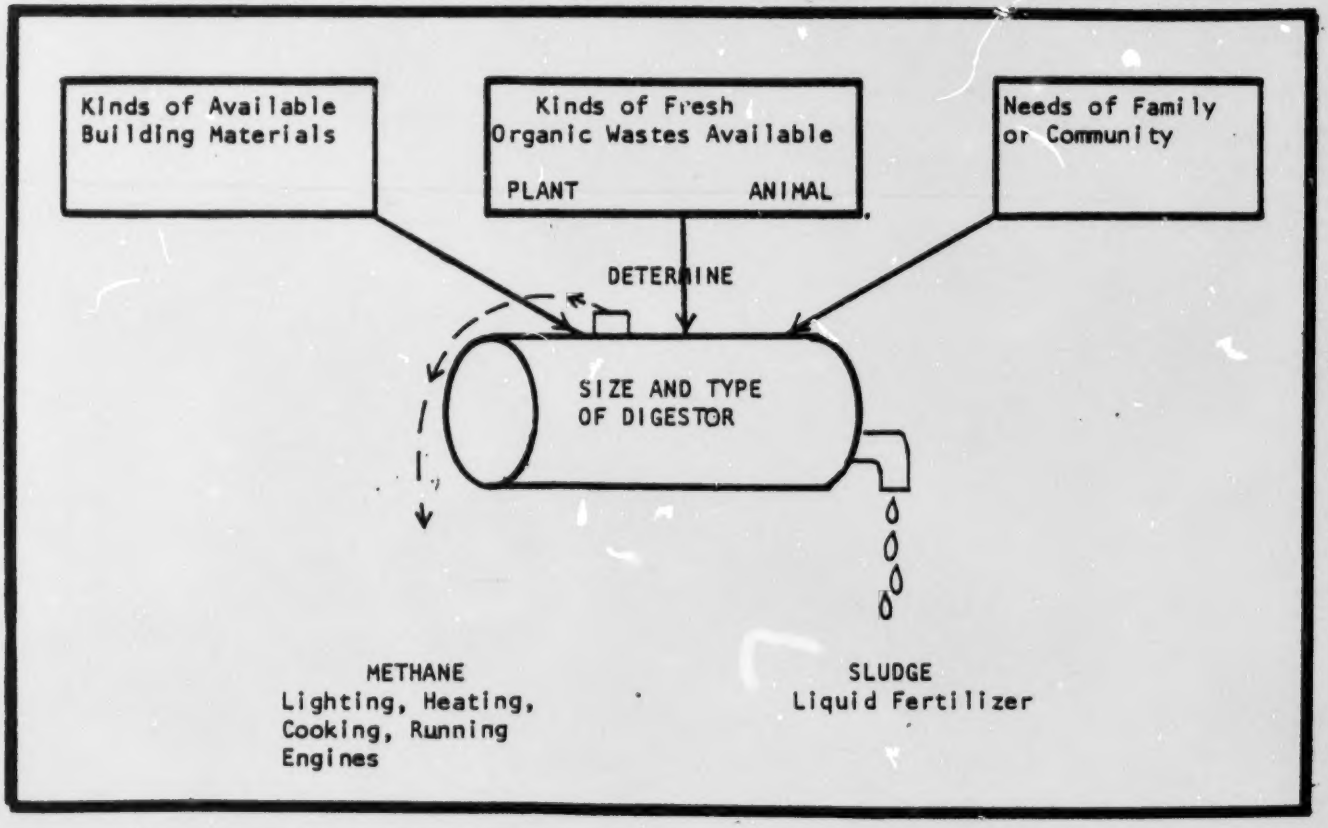


FIG.3 Related Considerations of a Digestor Operation

The first question involves the digestor itself. Which is just the heart of a whole energy system. The second question is synergistic; you can choose which products are to be generated by digestion and how to use them or feed them back to the digestor, creating an almost endless cycle if you wished (Fig 4). The model in Fig. 4 is idealized from oriental aquaculture systems and other ideas, both old and new. A single pathway can be developed exclusively (have your digestor produce only sludge to feed an algae pond) or you can develop

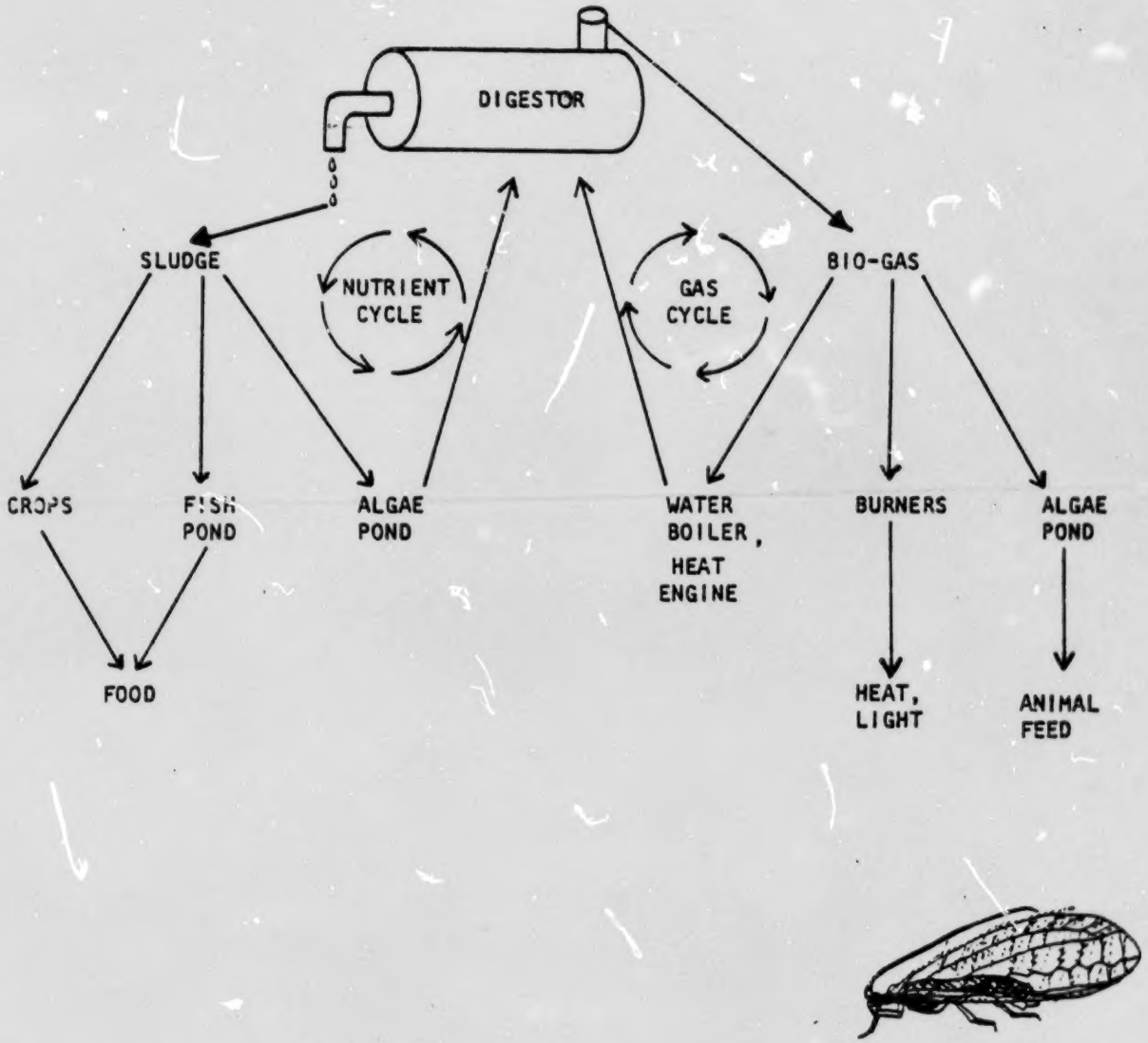


FIG.4 The Closed Nutrient System of a Complete Digestor Operation

the potential synergy (many possible systems working together as an integrated whole. Fig 5).

The small farmer can take a step towards ecological self-sufficiency by producing some of his fuel and fertilizer needs using a digester to convert local wastes.

Total dependence on conventional fuels, especially in rural areas, is likely to become a serious handicap in the years to come. But by producing

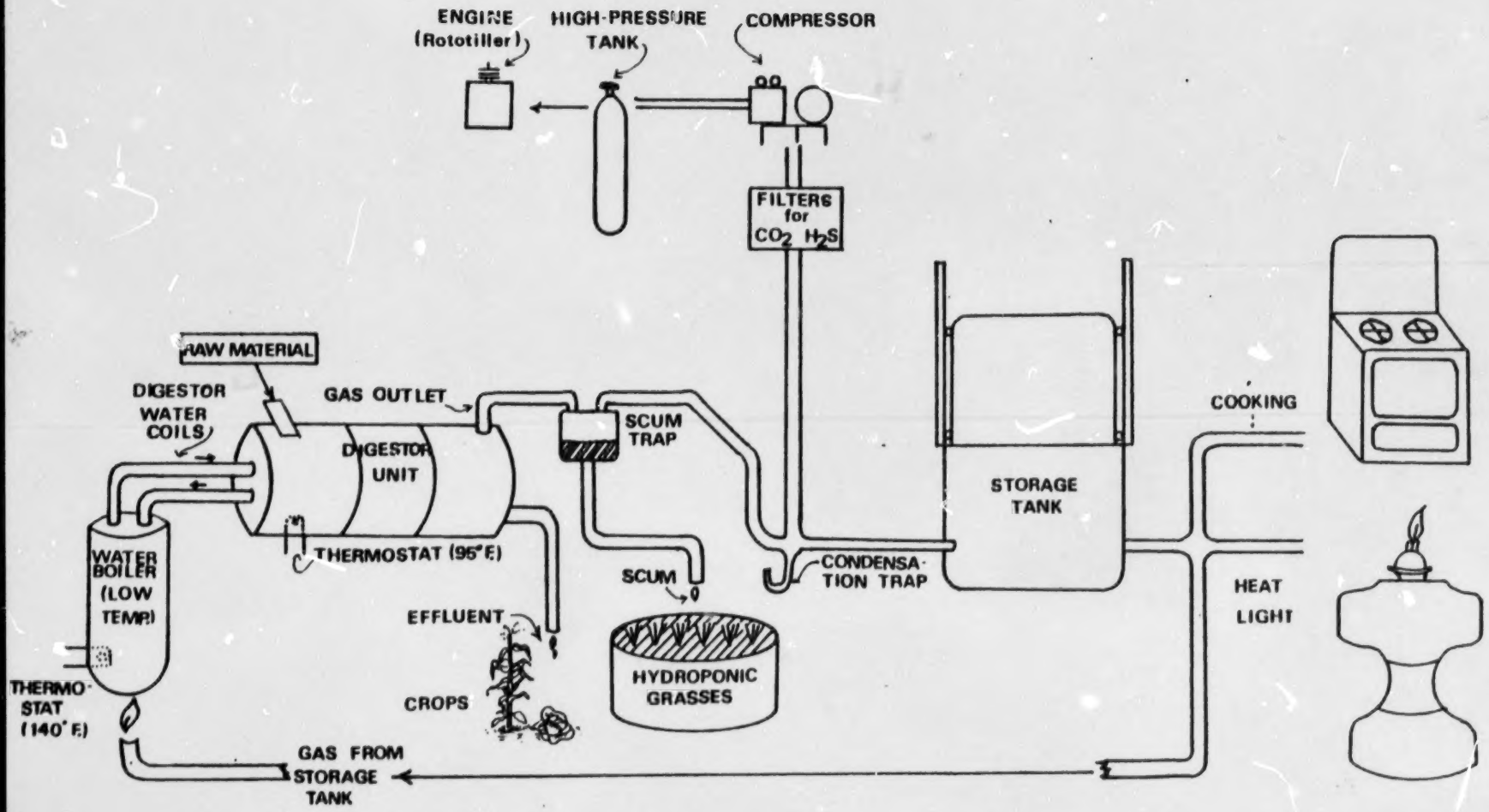


FIG.5 Integrated Organic Digester Operation
(Using 50 gallon drums for digestor)

energy from local resources, it is possible to be partially freed from remote sources of increasingly expensive fuel supplies.

China and India have both launched large-scale biogas programmes at various times and with varying levels of success. Once North Sea gas and oil have finished, we may yet see isolated communities in English farming areas coming to rely on such biogas plants for their heating and lighting.

The Role of Intergrated Biogas Systems in the Context of Food and Fuel Demands in Sri Lanka - by Prof. M. Amaratuga

Introduction

Sri Lanka, with a total land area of approximately 6.5 million hectares (16 million acres) has a population of around 14 million, about 70% of which may be described as rural and dependant on agricultural activities. By the year 2000 AD. the population is expected to have increased to nearly 24 million. The rapid growing expectations to the people have made heavy demands on the available supplies of food and fuel.

The country has no known sources of fossils fuels which can be conveniently exploited in the near future. Imported fuels, hydropower and fuel wood supply the entire energy requirements of the country. Fossil fuels are becoming prohibitively expensive; about 40% of the current export earnings are required for oil purchases. Hydropower resources are expected to be fully exploited by 1990; fuelwood which at present accounts for about 60% of the energy supplies is rapidly dwindling. Even though the prospects for the future appears to be somewhat bleak, the country is fortunate in having adequate supplies of water and plenty of sunshine. There is therefore, scope for the development of renewable bio-energy resources. This indirect method appears to be the most convenient technique for converting solar energy to useable forms.

Living standards and energy demands

There is much room for improving the general living standard of the people and in fact there is at present a great demand for such improvements throughout the country. Some of the areas where there are shortcomings and where bio-energy systems can provide a means of improvements are outlined below:

Nutrition: The earning capacity of a large section of the population does not permit the consumption of adequate amounts of milk foods or protein. This situation lends itself to advantageous exploitation; the intensive encouragement of dairy farming couples with inland fisheries projects will help to improve the general level of nourishment of the people while providing fertilizer and

fuel. At the same time, productive employment will be generated in the rural sector.

Health: Sources of water used for drinking and bathing are often polluted and the incidence of water borne diseases transmitted through insanitary disposal of human wastes is very high. The process of anaerobic digestion, involved in the production of biogas, destroys most pathogens and kill rates as high as 99-100% can be attained at temperatures prevailing throughout Sri Lanka. Subjecting human and animal wastes as well as crop residues to this process can drastically improve the health not only of humans but also farm animals and crops.

Fuel for cooking: Supplies of firewood, which is the most widely used fuel for cooking, are fast dwindling due to the lack of really effective programmes for re-afforestation. With the opening of new agricultural land, there is at first an abundance of fuelwood which is wastefully burnt. Subsequently, supplies become scarce. Moreover, serious environmental problems arise as a result of deforestation. Cooking with firewood has its health hazards too. Besides, fuelwood burning kitchens are blackened with soot and the homes are difficult to maintain. Biogas which is a clean burning efficient fuel provides an answer to this problem.

Fuel for lighting: Over 80% of the homes in the country use kerosene oil for lighting. Much of the foreign currency earnings of the country has to be used to import oil. In this context, gas lighting or electricity generated through biogas offers a valuable alternative.

Fuel for industry and transportation: Petrol engines can be operated entirely on biogas and the oil consumption of diesel engines can be reduced by as much as 80%. (Diesel engines can be modified for spark ignition and then they can be operated entirely on biogas). Biogas is not easily transportable and, therefore, it is more suitable for the operation of stationary engines for industrial purposes. For short distance transportation, however, biogas powered vehicles are feasible.

How to make an experimental methane digestor - from 'Methane' by Justin Cooke

You can convince yourself that fuel really is produced by rotting wastes with a simple experiment using materials to be found in any school science laboratory and in some homes. This is especially suitable for a school science class: the materials will already be available, so there'll be no cost. But don't be disappointed if it doesn't solve the energy crisis.

Experiment

All you need is some glass and rubber tubing as shown in the diagram, including one Y-shaped bit of tubing, a digestion chamber (e.g. a cider jug) a manometer, and some kind of gas collector, such as a polythene bag or bottle, and tubing clamps. Bend the glass tubing into the shapes required using a gas flame, and make a 'burner tip' by drawing out the heated end of a bit of glass tubing. Connect up the burner tip and the gas holder (which should be kept completely squashed and empty at this time) to the glass tubing. Fit the clamps and close them.

Now add the brew: chicken or horse manure mixed with water to make it liquid nearly always works. Vegetable waste, food scraps, any animal droppings etc., plus a good dollop of pond sludge (to make sure the bacteria you want are present) is also an excellent 'fuel'.

No methane will be produced until all the oxygen in the apparatus has been used up by aerobic bacteria - and a good seal is essential to stop more oxygen getting in. If you're impatient, flush out all the air first with gas from the tap. Even so it may be up to a week before any methane is produced.

For fast methane production you must keep the brew at around $35^{o}C$, but provided you keep it above $20^{o}C$ (warm room) enough methane will be produced for demonstration purposes. Because the digestor is so small you may need more energy keeping it at $35^{o}C$ than you get from it in methane. You could get round this by using heat from the sun. Place the digestor in a dark box with one face consisting of a pane of glass painted black on the outside, or blackened with thick soot or paper. Put this by a south facing window (or outside on hot days) with the blackened glass facing the sun (tilt the box to get the best angle). Provided the box is sealed against draughts, this is an effective way of keeping the digestor warm.

Alternatively you can keep the digestor warm with compost from grass-cuttings: simply with the digester in a bed of active compost.

After a few days, open the clamp to the burner tip (the clamp to the gas collector should still be closed), and see if you can ignite the escaping gas

with a match: if you can't, try again a few days later. When you can ignite the gas and are sure that methane production is under way (look at the manometer to check that the pressure is rising), open the clamp to the gas collector and let it gradually fill.

When the gas collector is full, you can burn the methane by putting a weight on the gas collector, opening the clamp to the burner tip, and lighting the gas as it comes out. You may have to adjust the weight on the gas collector to get the gas to burn properly: part of a brick should be about right.

The whole point of methane production is to get useable energy, so get a tripod stand from your science laboratory other suitable structure to use the methane to boil a kettle or cook a meal. Yes, methane digestors really do make energy!!

When the gas collector is almost empty or the manometer shows the pressure to be dropping, close the clamp on the tube to the burner tip and let the digester start producing methane again. Product should continue for a few weeks, and you may fill up the gas collector several times.

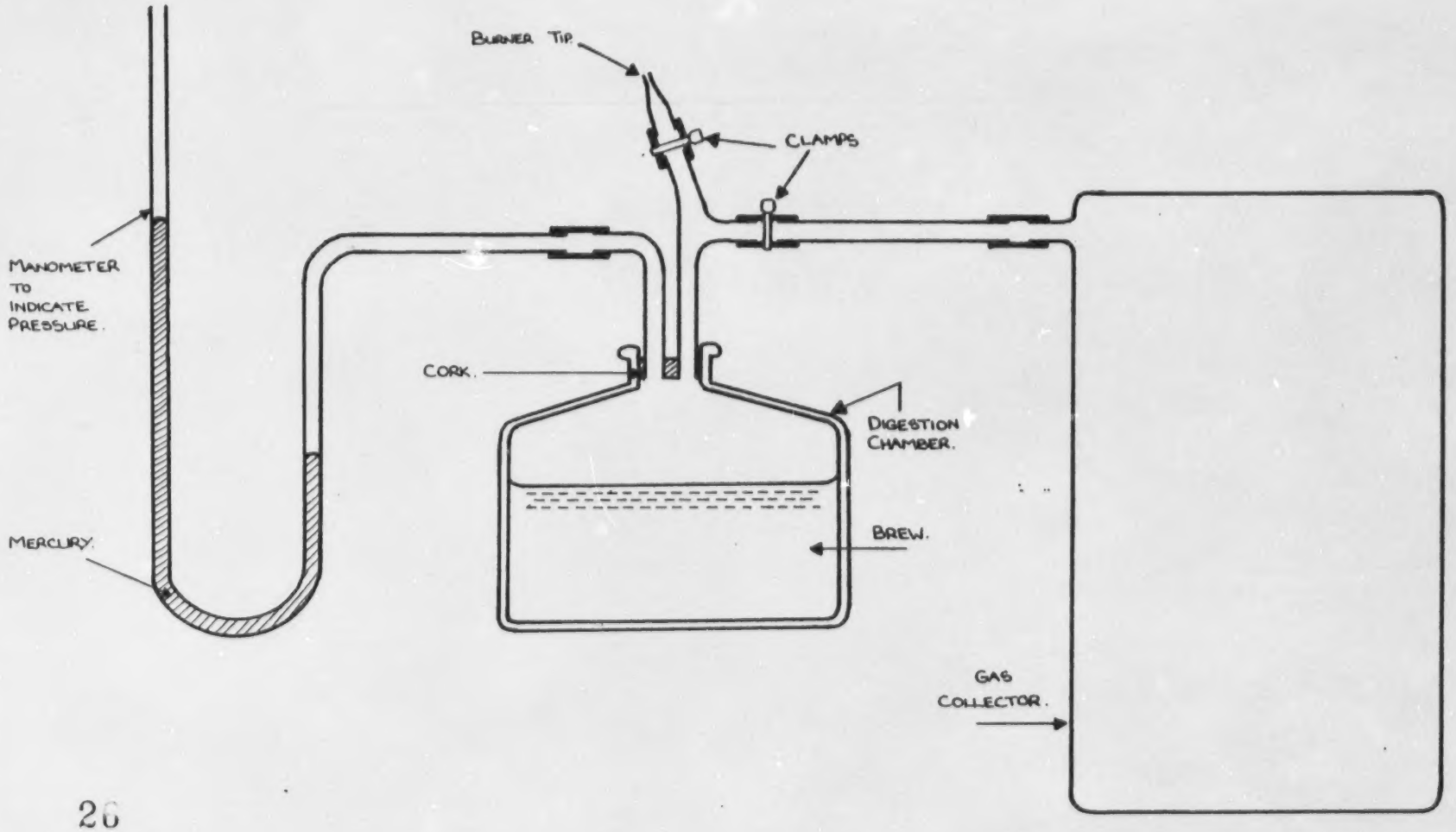
When methane production stops, it's time to make the next batch - pour out the old brew into someone's garden (it's an excellent fertilizer) and refill the digestion chamber.

Safety Warning

Methane forms an explosive mixture with air. The digester should be kept in a ventilated room with no naked flames near it. It shouldn't be ignited directly from the digestor without first ensuring that there is no air in the mixture. Methane is most explosive when it is mixed with about 12 times its own volume of air.

Ref: Justin Cooke.

HOW TO MAKE AN EXPERIMENTAL METHANE DIGESTOR.



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ACKNOWLEDGEMENTS

The Third World Science Project has been supported by a number of agencies and has drawn upon the expertise and goodwill of a vast number of individuals.

Pilot Project 1979-80 supported by the Overseas Development Fund

Writers: Trevor Roach, Philip Bladon Typing: Carole Johns
Graphics: George Robinson

Main Project 1981-82 supported by the Manpower Services Commission

Writers: Natalie Jones, Wyn Hughes Typing: Marjorie Eccles
Graphics: Karen Moss

In this phase of the project 100 sets of 14 Units have been produced and distributed to schools, teachers' centres and teacher training establishments. Draft material has been prepared for further Units.

Dissemination 1982-3 supported by the University of Wales

Faculty of Education Research and Publications Fund

Printing: University College of North Wales Print Unit

Distribution: The Centre for World Development Education, Buckingham Palace Road, London SW1W 9SH

The continued support and encouragement of Mr Dick Meakins of the CWDE is gratefully acknowledged

Sources The ideas and information incorporated in these Units come mainly from science teachers who are, or have been, teaching abroad. In some cases their pupils have also contributed. Some are known to us personally, others only through their letters, articles and books. We are very grateful to them all.

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